IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:
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For: ELECTROPLATING COMPOSITIONS AND METHODS FOR ELECTROPLATING
Examiner: Edna Wong
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REPLACEMENT APPEAL BRIEF SUMMARY
SUPPLEMENTAL RESPONSE TO NON-COMPLIANT APPEAL BRIEF

This is in supplement to the prior Response filed in reply to the Notification of Non-Compliant Appeal Brief following telephone interviews with the Examiner and the Appeals Specialist Jennifer Michener.

V. Summary of Claimed Subject Matter

The independent claims are supported in the specification of the present application at least at the below cited portions (cites following each element). Please also review the summary text below for a clear understanding of the presently claimed invention.

Claim 1 recites an aqueous-based electroplating composition comprising:
about 35 to about 60 g/L copper; (Spec. p. 9, ll. 21-26)
about 65 to about 150 g/L sulfuric acid; (Spec. p. 9, ll. 21-26) and
a glycol-based suppressor. (Spec. p. 11, ll. 4-10)

Claim 6 recites an electroplating composition comprising:
about 35 to about 60 g/L copper; (Spec. p. 9, ll. 21-26)
about 65 to about 150 g/L sulfuric acid; (Spec. p. 9, ll. 21-26)
about 2 to about 30 ml/L of a copper-deposition suppressor and wherein the balance of the composition is water. (Spec. p. 11, ll. 4-20)

Claim 15 recites an aqueous electroplating composition comprising:
about 35 to about 60 g/L copper; (Spec. p. 9, ll. 21-26)
about 65 to about 150 g/L sulfuric acid; (Spec. p. 9, ll. 21-26)
about 2 to about 30 ml/L copper-deposition accelerator; (Spec. p. 11, l. 21 – p. 12, l. 9)
about 2 to about 30 ml/L copper-deposition suppressor; (Spec. p. 11, ll. 4-20)
about 40 to about 60 ppm hydrogen chloride. (Spec. p. 10, l. 17 – p. 11, l. 1)

Claim 19 recites an electroplating composition comprising:
about 45 to about 55 g/L copper; (Spec. p. 9, ll. 23-26)
about 75 to about 120 g/L sulfuric acid; (Spec. p. 9, ll. 23-26)
a copper-deposition suppressor; (Spec. p. 11, ll. 4-20)
a copper-deposition accelerator. (Spec. p. 11, l. 21 – p. 12, l. 9)

Claim 26 recites an electroplating composition comprising:

an aqueous mixture of copper and sulfuric acid wherein the ratio in g/L of solution of copper to acid is equal to about 0.4 to about 0.8; (Spec. p. 9, ll. 4-13; p. 31, ll. 4-8)

a copper-deposition suppressor (Spec. p. 11, ll. 4-20) and a copper-deposition accelerator. (Spec. p. 11, l. 21 – p. 12, l. 9)

Claim 34 recites an electroplating composition comprising:

an aqueous-based mixture of copper and sulfuric acid wherein the ratio in g/L solution of copper to acid is equal to about 0.3 to about 0.8; (Spec. p. 9, ll. 4-13)

a copper-deposition suppressor; (Spec. p. 11, ll. 4-20)

a copper-deposition accelerator; (Spec. p. 11, l. 21 – p. 12, l. 9)

wherein only electroplating compositions comprising the aqueous-based mixture of copper and sulfuric acid wherein the ratio in g/L of copper to acid is equal to about 0.3 to about 0.8 are used to deposit copper on a workpiece. (Spec. p. 9, ll. 4-13; p. 32, ll. 1-9)

Claim 35 recites an electroplating composition comprising:

an aqueous mixture of copper and sulfuric acid wherein the copper concentration in the composition is within about 60% to about 90% of its solubility limit when the sulfuric acid concentration is from about 65 to about 150 g/L; (Spec. p. 9, ll. 14-26)

a copper-deposition suppressor; (Spec. p. 11, ll. 4-20)

a copper-deposition accelerator. (Spec. p. 11, l. 21 – p. 12, l. 9)

Claim 44 recites an electroplating composition comprising:

about 40 g/L copper; (Spec. p. 9, l. 27 – p. 10, l. 4)

about 100 g/L sulfuric acid; (Spec. p. 9, l. 27 – p. 10, l. 4)

a copper-deposition suppressor; (Spec. p. 11, ll. 4-20)

a copper-deposition accelerator. (Spec. p. 11, l. 21 – p. 12, l. 9)

Claim 53 recites an aqueous electroplating composition comprising:

about 50 g/L copper; (Spec. p. 9, l. 27 – p. 10, l. 4)

about 80 g/L sulfuric acid; (Spec. p. 9, l. 27 – p. 10, l. 4)

about 2 to about 10 ml/L copper-deposition suppressor; (Spec. p. 11, ll. 4-20)

about 2 to about 8 ml/L copper-deposition accelerator. (Spec. p. 11, l. 21 – p. 12, l. 9)

Claim 55 recites a method for plating a workpiece comprising:

providing a workpiece having a plurality of device features including a seed layer wherein the plurality of device features is to be metallized; (Spec. p. 5, l. 1- p. 6, l. 9)

electrolytically depositing copper within the plurality of device features (Spec. p. 5, ll. 16-20; p. 17, l. 24 – p. 19, l. 5; p. 20, l. 15 – p. 21, l. 26; Figs. 2(a)-2(e), 3(a)-3(e), 4(d)-4(f), 5(b), 6(b) and 8(a)-8(d)) utilizing an electroplating composition comprising about 35 to about 60 g/L copper, about 65 to about 150 g/L sulfuric acid, (Spec. p. 9, ll. 21-26) and a glycol-based suppressor (Spec. p. 11, ll. 4-10)

Claim 63 recites a method for plating a workpiece comprising:

providing a workpiece having a plurality of device features including a seed layer wherein the plurality of device features is to be metallized; (Spec. p. 5, l. 1- p. 6, l. 9)

electrolytically depositing copper within the plurality of device features (Spec. p. 5, ll. 16-20; p. 17, l. 24 – p. 19, l. 5; p. 20, l. 15 – p. 21, l. 26; Figs. 2(a)-2(e), 3(a)-3(e), 4(d)-4(f), 5(b), 6(b) and 8(a)-8(d)) utilizing an electroplating composition comprising from about 35 to about 60 g/L copper, from about 65 to about 150 g/L sulfuric acid (Spec. p. 9, ll. 21-26), from about 2 to about 30 ml/L copper-deposition accelerator (Spec. p. 11, l. 21 – p. 12, l. 9), from about 2 to about 30 ml/L copper-deposition suppressor (Spec. p. 11, ll. 4-10) and from about 40 to about 60 ppm hydrogen chloride. (Spec. p. 10, l. 17 – p. 11, l. 1)

Claim 66 recites a process for applying a metallization interconnect structure, comprising:

providing a workpiece on which a metal seed layer has been formed using a first deposition process and enhancing the seed layer by electrochemically depositing additional metal on the seed layer within a principal fluid chamber of a reactor to provide an enhanced seed layer (Spec. p. 18, 1. 3 – p. 20, l. 14; Figs. 8(a)-8(d)) using a deposition process comprising supplying electroplating power to a plurality of concentric anodes disposed at different positions within the principal fluid flow chamber relative to the workpiece (p. 13, l. 10 – p. 16, l. 2); and

electrolytically depositing a metal on the enhanced seed layer utilizing an electroplating composition comprising about 35 to about 60 g/L copper, about 65 to about 150 g/L sulfuric acid, (Spec. p. 9, ll. 21-26) and a glycol-based suppressor (Spec. p. 11, ll. 4-10)

Claim 68 recites a process for applying a metallization interconnect structure, comprising:

providing a workpiece on which a metal seed layer has been formed (Spec. p. 5, l. 1- p. 6, l. 9) and enhancing the seed layer by electrochemically depositing additional metal on the seed layer (Spec. p. 18, l. 3 – p. 20, l. 14; Figs. 8(a)-8(d)) within a principal fluid chamber of a reactor to provide an enhanced seed layer using a deposition process comprising supplying electroplating power to a plurality of electrodes within the principal fluid flow chamber, (Spec. p. 14, l. 10 – p. 16, l. 2)

independently controlling the supply of electrical power to the at least two electrodes during enhancing of the seed layer; (Spec. p. 15, ll. 18-21)

electrolytically depositing copper on the enhanced seed layer under conditions in which the deposition rate of the electrolytic deposition process is substantially greater than the deposition rate of the process used to enhance the metal seed utilizing an electroplating composition comprising a mixture of copper and sulfuric acid wherein the ratio in g/L of copper to acid is equal to about 0.4 to about 0.8 (Spec. p. 9, ll. 4-13; p. 31, ll. 4-8)

a copper-deposition suppressor (Spec. p. 11, ll. 4-20) and a copper-deposition accelerator. (Spec. p. 11, l. 21 – p. 12, l. 9)

In the production of semiconductor integrated circuits, metal layers on a workpiece (such as wafers) are deposited to serve as interconnect metallization that electrically connects various devices on the integrated circuit to one another (p. 1, ll. 10-14).[1] Electrodeposition may be used to deposit the metal layers (p. 2, ll. 17-21).

Electroplating compositions often comprise copper (e.g., copper sulfate) and an acid (e.g., sulfuric acid) (p. 2, ll. 26-27). The acid provides the high ionic conductivity to the plating composition necessary to achieve high throwing power. "Throwing power" refers to the ability

[1] Please note: Although citations to page and line numbers of the application are provided for support of the summary text herein, those may not be the only place within the specification such items are discussed and are not chosen to carry more or less interpretive weight than other, not cited, mentions in the specification.

of an electroplating composition to deposit metal uniformly on a wafer substrate (p. 2, l. 27 – p. 3, l. 3). If the composition has a low concentration of copper and a high concentration of acid, throwing power of the composition is improved (p. 3, ll. 3-7).

Conventional plating solutions comprise either relatively high acid concentration to low copper concentration ratios *or* low acid concentration to high copper concentration ratios (p. 3, l. 7 – p. 4, l. 25; p. 8, ll. 24-28). There is poor metal filling capability when using a plating composition superior in throwing power and coating uniformity (i.e., high acid to low copper compositions) to fill copper into high aspect ratio features (p. 4, ll. 1-8; p. 8, ll. 24-28). High aspect ratio features refer to the ratio of the depth to width of the interconnect features, e.g., trenches or contact holes (p. 4, ll. 1-8; p. 8, ll. 24-28). But using a conventional low acid, high copper plating composition provides inferior throwing power and suppressed additive activity, resulting in unplated areas within features (p. 4, ll. 8-10; p. 8, ll. 24-28).

Attempts to address the problems introduced using the conventional plating compositions (i.e., compositions having a high acid concentration to low copper concentration of or visa versa) are not satisfactory. Such attempts include the inclusion of additives such as suppressors, accelerators, and/or levelers (p. 4, ll. 23-28).

Applicants, contrary to conventional wisdom, developed compositions including copper and acid at previously avoided relative concentrations. Applicants' compositions have relatively low acid concentrations to relatively low copper concentrations as compared to the prior art (p. 9, ll. 1-3). Put another way, Applicants' compositions have relatively low and narrow acid to copper concentration ratios.

Using comparative testing, Applicants confirmed that their invention provided depositions far exceeding the prior art compositions. Comparative tests are shown in the specification on page 22, line 1 through page 27, line 4. For comparison testing, the prior art electroplating compositions (which notably are almost identical in composition to the art cited in the Office actions against the present claims as discussed below) were tested under the same conditions with identical additives at the identical additives concentrations. The only parameter varied between the currently claimed compositions and the prior art compositions were the relative concentrations of acid to copper (p. 22, ll. 16-17). The test results reported for the compositions claimed having relatively low acid to copper concentration ratios (unlike the high ratios of the prior art) indicate the unexpected superior results of the currently disclosed

compositions (p. 22, l. 22 – p. 23, l. 6; p. 23, ll. 7-14; p. 24, l. 4 – p. 25, l. 2 – for ease of reference, these pages are attached hereto as XII Appendix – Comparative Tests as Disclosed in the Specification).

Claimed embodiments of Applicants' electroplating compositions comprise:

> an aqueous mixture of copper and sulfuric acid wherein the ratio of copper concentration to sulfuric acid concentration is from about 0.3 to about 0.8 (p. 9; ll. 4-13)

or

> wherein the compositions have certain, relatively narrow acid and copper concentration ranges, for example, about 65 to about 150 g/L acid and about 35 to 60 g/L copper (i.e., a 1.1 to 4.3 acid to copper ratio) (p. 9, ll. 21-26)

and other narrower ratio ranges. Certain of Applicants' claimed compositions also comprise:

> an aqueous mixture of copper and sulfuric acid wherein the copper concentration is within about 60% to about 90% of its solubility limit when the sulfuric acid concentration is from about 65 to about 150 g/L (p. 9; ll. 14-21).

Other compositions of even narrower ranges and relative concentrations of acid to copper are also disclosed (p. 9, l. 8 – p. 10, l. 4) and claimed in certain independent claims. These compositions may also include conventional additives, such as accelerators, suppressors, halides and/or levelers (p. 10, ll. 11-18; p. 11, ll. 4-5; p. 11, ll. 21-22; p. 12, ll. 23-26).

Respectfully submitted,

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